BIOCONVERSION OF MUNICIPAL SOLID WASTE (MSW) EMPLOYING BIOINOCULANTS AND EARTHWORMS

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DEDICATED

TO MY

FAMILY

CERTIFICATE

This is to certify that the thesis entitled *"Bioconversion of Municipal Solid Waste (MSW) employing bioinoculants and earthworms"* submitted by Mr. Kaviraj has been prepared under our guidance with the rules and regulations of Indian Institute of Technology Delhi, India. The research report and results presented in this thesis have not been submitted for any degree or diploma in any other institute or university.

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ABSTRACT

The rapid urbanisation world over demands that a suitable and cost effective technology should be identified and evaluated for the environmentally safe treatment and disposal of Municipal Solid Waste (MSW). Bringing this into consideration, MSW could be utilized as a substrate for making better quality vermicompost, and as an alternative substrate for cultivation of edible fungi (mushroom). Bioincolants play an important role in nutrient recycling, rapid composting and also as a biocontrol agent in crop production. So it was considered of interest to explore the possibility of using nitrogen fixing bacteria and phosphate solubilizing fungi along with the earthworms to hasten the rate of MSW stabilization and improving the quality of vermicompost. In general, Eisenia fetida (non-indigenous) species of earthworm is used for vermicomposting, and work on the use of indigenous species for this purpose is very scanty. In view of long term ecological impacts of using non-indigenous species, the studies on the indigenous species assume great significance.

Therefore, in search of an integrated system for MSW management, this study was taken up with three specific objectives: i) To conduct comparative studies on performance and efficacy of indigenous (Lampito mauritii) and non-indigenous species (E. fetida) of earthworms, in vermicomposting of MSW; ii) To assess the best combination of bioinoculants (P. chrysogenum, P. funiculosum and A. chroococcum) and earthworms, and to study their role in quality of compost (Nitrogen, Phosphorus, Potassium, enzymes and heavy metals); and iii) To cultivate edible fungi (i.e. P. sajor caju on fresh MSW and A. bisporus on vermicomposted MSW supplemented with lignocellulosic materials) and study the role of bioinoculants and plant growth hormones on the yield and quality of mushroom.

Prior to the vermicomposting experiments, collection and identification of indigenous earthworm species was done from various locations of Delhi. Total 6 indigenous species were found prevailing in Delhi region and among these, L. mauritii was found more widely distributed and hence it was selected for further studies. After composting of MSW for 60 days a maximum number of E. fetida (59.3) and L. mauritii (43.0) was found in the substrate inoculated with A. chroococcum. In this context it may be noted that athough the

multiplication rate of L. mauritii is slower than E. fetida, the weight of L. mauritii is greater than E. fetida, suggesting that total L. mauritii earthworm mass is either at par or likely to be slightly lower compared to E. fetida. This interesting experimental observation would help in assessing the true potential of indigenous earthworm species and scope of further enhancement using bioinoculants.

Maximum reduction in percentage of Total Organic Carbon (31.3 to 16.7%) and maximum increase in percentage of Total Kjeldhal Nitorgen (1.23 to 3.35%), phosphorus (0.21 to 1.88%) and potassium (0.32 to 1.53%), were noted for E. fetida inoculated with A. chroococcum and P. chrysogenum. The enzymatic activities of the β-glucosidase, urease and phosphatase, after 60 days, were observed lowest in the substrate inoculated with the consortia of E. fetida and bioinoculants, confirming the role of bioinoculants in vermicomposting. In this context it may be noted that the concentration of heavy metals in matured vermicompost was found to be less than the initial concentration in the MSW mixed substrates. Also, indigenous species of earthworms exhibited better performance in reducing the concentration of certain heavy metals in vermicompost.

The MSW supplemented with R. communis (1:3) produced the maximum BE (60.5%), at par with 60.3% of MSW+Rc (1:2). The chemical characteristics of SMS (Spent Mushroom Substrates) indicated that maximum percent decrease in TOC (26.0%), cellulose (28.3%), hemicellulose (26.4%) and lignin (38.3%), and percent increase in TKN (26.5%), phosphorus (14.3%) and potassium (20.3%) was obtained with the supplementation of R. communis in the ratio of 1:3. Maximum protein content (28.5%) was observed in the mushroom fruit bodies harvested from the substrate MSW+Ma (1:3) and maximum percentage of lipids (3.26%) seen in fruit bodies harvested from MSW+Rc (1:3). Supplementation of the combination of PGHs (IAA, GA_3 and KIN) into the substrates improved BE (72.3%) of P. sajor-caju. The chemical characterization of SMS indicated that inoculation of A. chroococcum gave maximum increased percentage of TKN whereas for increase in phosphorus and potassium, consortia of GA_3+IAA+KIN proved best. The maximum protein content (34.2%) was obtained in the fungi fruit bodies harvested from the substrates inoculated with A. chroococcum.

Possibilities were explored for the cultivation of A. bisporus, by using vermicompost, prepared from decomposition of MSW employing E. fetida and L. mauritii, instead of *synthetic compost prepared from traditional substrate (wheat/rice straw). Maximum yield of A. bisporus in terms of BE (27.7%) was obtained from the substrate combination of MSW+Rc (1:3) which was vermicomposted using E. fetida. The analysis of Spent Mushroom Substrate (SMS) showed maximum increases of nitrogen (23.4%), phosphorus (14.8%) and potassium (27.4%) in the substrates MSW+Rc (1:3), vermicomposted using E. fetida. Similarly, maximum reduction, over initial values in the substrates, of organic carbon (37.3%), cellulose (50.5%), hemicellulose (55.3%), and lignin (54.9%) were observed in MSW+Rc (1:3). With the inoculation of the combination of GA_3, IAA and Kinetin, maximum BE (25.9%) which is 52.3% higher over control, was achieved. The supplementation of PGHs in combination (GA_3, IAA and KIN) caused maximum decrease in TOC, cellulose, hemicellulose and lignin. However, maximum increase in nitrogen content (0.96 to 1.78) was observed with the inoculation of A. chroococcum individually.*

The concentration of tested heavy metals in the fungi fruit bodies of P. sajor-caju was always found under the permissible limits for food intake. For A. bisporus the maximum concentration of lead (2.12 mg/kg) was found when harvested from E. fetida vermicomposted MSW (100%). The maximum concentration of Zn (11.2 mg/kg), Ni (3.1 mg/kg) and Cu (1.6 mg/kg) was observed in fungi fruit bodies harvested from MSW+Ll (1:2), while the fruit bodies harvested from substrate combination of MSW+Ll (1:3) and MSW+Ll (1:2), showed a maximum concentration of cadmium (0.9 mg/kg). Although BE for L. mauritii was lower than E. fetida but L. mauritii, it was found that caused higher reduction of concentration of certain heavy metals in the fruit bodies. This aspect needs to be investigated further.

The present study clearly reveals the possibilities to use MSW as a good quality of vermicompost and an alternative substrate for the cultivation of edible fungi. The comparative experimental findings for the efficacy of two earthworm species have provided an improved understanding of the potential of previously unexplored indigenous species of earthworms for vermicomposting of MSW and their role in heavy metal uptake.

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